THE BELL SYSTEM TECHNICAL JOURNAL
Vol. 61, No. 9, November 1982
Printed in U.S.A.

D4 Digital Channel Bank Family:

Overview

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(Manuscript received June 25, 1981)

This article presents an overview of the D4 Digital Bank Family and introduces a series of articles on the subject. The D4 family represents a collection of features and network applications derived from a single design, the basic D4 digital terminal.

In 1962, the first digital carrier system was introduced into the telephone plant as an alternative to metallic interoffice trunks. On this system 24 voice signals are amplitude sampled, time shared, and digitally encoded; each direction of transmission is on a single pair of copper wires. This results in a twelve-to-one improvement in efficiency in the use of copper pairs as compared with the two-wire metallic trunks. The first-generation channel bank is designated the D1 bank, the D1 standing for Digital, first generation. The D1 bank performs the time-shared sampling and digital encoding of the 24 voice signals into a 1.544 million pulses per second signal.

Since 1962 four generations of digital banks bave been developed. The present generation—the subject of this special issue—is designated the D4 bank, and was introduced into the field at the end of 1976.

The success of digital banks and associated transmission facilities can be expressed by their penetration into the metropolitan interoffice network. Today, the digital facilities account for about 35 percent of the total metropolitan interoffice trunks. In terms of voice-circuit miles, the digital facilities provide 80 percent of the total, that is, 100 million out of a total of 125 million voice-circuit miles. On a growth basis, the digital implementation accounts for about 75 to 80 percent of this market. By the end of 1980, the Bell Operating Companies

(BOCS) were supplied approximately ten million digital bank channel ends consisting of D1, D2, D3, and the D4 families.

The development of each successive generation of D banks took place as advancements in component and circuit technology offered opportunities for new features, increased compactness, decreased power dissipation, and improved maintenance and reliability. These factors all led to better overall cost-effectiveness. Largely as a result of following the technology learning curve, it was possible, over tbe period 1962 to 1980, to lower the furnished cost to the BOCS of a typical interoffice exchange digital trunk by a factor of more than three.

The first three generations, D1, D2, and D3, offered a relatively modest set of features. For example, toll quality transmission started with D2. (It was also offered later on an optional basis for D1 as tbe D1D bank.) As another example, starting with D1, an increasing complement of special functions, normally provided through separate metallic facility terminals, was incorporated into the banks in the form of special service channel-unit circuit packs. The experience gained from these optional features in previous generations of banks led to the decision, during the planning for the D4 bank in 1974 and 1975, to provide for an architecture capable of accommodating on a plug-in basis an extremely broad complement of functions and features heretofore furnished by equipment in separate bay lineups. In time, this initial plan was broadened to include the design of new functions at the plug-in level, e.g., error correction for digital data channels, and at the systems level, e.g., *SLC**-96 carrier system for loop applications.

Two examples shall serve to illustrate the basic concept. The first is the D4 built-in multiplex. Tbe D4 bank is designed for a capacity of 48 channels (the previous generation banks interfaced only 24-channel systems) with optional multiplex plug-ins to deliver either two DS-1 signals to two T1 24-channel lines, or one DS-1C signal to a T1C 48-channel line. [DS-1 is a 1.544-Mb/s bit stream containing 24 pulse code modulation (PCM) coded channels, and DS-1C is a 3.152-Mb/s bit stream containing 48 PCM coded channels.] By interconnecting two D4 banks and by employing another set of multiplex plug-ins, a DS-2 signal is generated for transmission over the T2 96-channel system. (DS-2 is a 6.312-Mb/s bit stream containing 96 PCM coded channels.) If yet another set of plug-ins containing lightwave transmitters and receivers is used, a signal at the DS-2 information rate is generated for transmission over lightguide. The concept of generating various digital signal rates by employing optional plug-ins in the bank results in significant economies as compared with providing the multiplex function with segregated equipment in a separate bay lineup. The econ-

* *SLC* is a trademark of Western Electric.

omies reflect not only the reduced material price and installation costs to the BOCs, but also shortened installation intervals.

A second example is the provision of digital data channels by means of a "dataport" plug-in. This dataport plug-in fits into the physical space of a D4 channel unit, even though the circuitry of the dataport is several times as complex. The dataport plug-in provides functions that otherwise require entire shelves of equipment designed in the early 1970s. This is achieved largely by increased component count per unit area in silicon integrated circuit technology and by the flexibility afforded by the D4 architecture. As we mentioned, the dataport actually incorporates features that are not available in earlier designs. An example is error correction of the digital data signals, which has not only the advantage of improved performance but more importantly shortens installation intervals by eliminating the need to test and select the T-carrier facilities for error performance.

The concept of offering a wide variety of capabilities on an optional basis through the basic D4 architecture proved very successful. It began a new era characterized by expansion of applications through integrating interfaces with other parts of the network. The result is a ubiquitous, flexible, and cost-effective realization of capabilities, which would not have been achieved by separate pieces of equipment. The ubiquity is a consequence of the pervasive deployment of D4 banks in the network. The flexibility stems from the plug-in nature of the realizations. The cost-effectiveness derives from benefits gained in many different phases in the life cycle of equipment, viz., design, manufacture, field engineering, installation, operation, maintenance, and network rearrangements.

When viewed in its entirety, this approach is seen to have brought about the "D4 Digital Bank Family," called the "D4 family" for short, which grew to include the following broad capabilities:

(*i*) Integrated interfaces for the digital line facilities, with interconnection capability for T1, T1C (two options), T2, and lightguide, using a set of D4 common plug-ins.

(*ii*) Integrated interfaces to metallic facilities for the provisioning of special access and private line arrangements by a set of D4 plug-ins called special service channel units.

(*iii*) Direct access for the Digital Data System for the Dataphone* Digital Service (DDS) by a set of plug-ins called "Dataports."

(*iv*) Integrated interfaces for the No. 1, 2, and 3 ESS (Electronic Switching Systems) trunks through channel unit plug-ins.

(*v*) A D4-technology-based subscriber digital carrier system, *SLC*-96, designed for "feeder" cable relief in loop applications. The first

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* *Dataphone* is a service mark of AT&T.

three integrated interfaces for the digital line facilities were available with the initial D4 offering. The T2 and the lightguide interfacea were offered in 1979. Dataports were introduced into service in late 1978 and the *SLC*-96 system in the spring of 1979.

The first two articles in this issue describe the basic D4 bank and a maintenance bank designed to test and monitor D4 plug-ins. The basic D4 bank is the kernel for expanded applications, described in the fourth through the seventh articles: namely, the Subscriber Loop Carrier, the *SLC*-96 System, and the dataports for the Digital Data System. Articles eigbt through ten deal with technology: the physical design aspects of the D4 family, custom silicon integrated circuit design, and thin-film active filters.